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CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

MINES BRANCH

OTTAWA

MINERAL SCIENCES DIVISION

INTERNAL REPORT MS-65-60

ATTENDANCE AT THE 67th ANNUAL MEETING OF THE AMERICAN CERAMIC SOCIETY, HELD AT PHILADELPHIA, PA., MAY 1 to 6, 1965

by

Norman F.H. Bright

Physical Chemistry Section

MINES BRANCH

Mineral Sciences Division

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(Date) June 24, 1965

Internal Report No. MS-65-60

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by

Norman F.H. Bright*

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INTRODUCTION

This report covers the attendance of Dr. Norman F.H. Bright at the 67th Annual Meeting of the American Ceramic Society, which was held in Philadelphia, Pennsylvania, from Saturday, May 1 to Thursday, May 6, 1965 inclusive. The writer is a member of the Society.

Attendance at the meeting involved the writer in an absence from his office in Ottawa of almost 5 working days, and entailed the expenditure of approximately $166.00, predominantly in U.S. funds. This sum covered the cost of registration, accommodation, meals, a plant visit and certain other functions associated with the meeting, but did not include the cost of transportation, which was by train on travel warrant for both outward and return journeys via Montreal, Albany and New York City.

The membership of the American Ceramic Society is divided into several Divisions, all of which held their own technical sessions, often

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involving concurrent sessions for a given Division. These Divisions are:

a) Basic Science;

b) Ceramic-Metal Systems;

c) Design;

d) Electronics;

e) Glass;

f) Materials and Equipment;

g) Refractories;

h) Structural Clay Products;

j) White Wares.

The writer's interest was predominantly in the proceedings of the Basic Science Division, to which he is affiliated, though certain papers presented before other Divisions, notably the Electronics Division, were of interest and were attended.

Joint meetings of two Divisions were held on some occasions, to deal with subjects of interest to both participating Divisions. There was also a group of "Society Symposia", dealing with topics that cut across the interest of several Divisions. Certain of these meetings also were attended. The titles of these Society Symposia were:

I. Nuclear Ceramics (5 half-day sessions)

Session 1: Irradiation Effects and Nuclear Poisons.

Session 2: Fabrication Techniques.

Session 3: Oxide Fuels.

Session 4: Non-Oxide Fuels.I

Session 5: Non-Oxide Fuels.II.

II. Fibrous Composites (3 half-day sessions)

Session 1: Inorganic Fibres and Composites I.

Session 2: Inorganic Fibres and Composites II.

Session 3: Fibre Properties and Evaluation Methods.

III. Gases in Glass (4 half-day sessions)

Session 1: Solubility and Transport Phenomena.

Session 2: Reboil Phenomena.

Session 3: Kinetics and Mechanisms of Fining.

Session 4: Associated Topics.

IV. Laser Materials (2 half-day sessions)

V. Thin Films and Ceramic Substrates (2 half-day sessions)

The Electronics and Ceramic-Metal System Divisions held a half-day joint session dealing with seals while the Materials and Equipment Division held a joint half-day session with the White Wares Division to discuss fine particle systems and fine particle sizing.

Almost the whole of the sessions were accommodated in the Bellevue-Stratford Hotel, which is a large but old-fashioned building in down-town Philadelphia. This hotel, however, was unable to provide sufficient residential accommodation for the large registration of participants, who numbered slightly over 3,000. Numerous other hotels were used, not all of them very close to the Bellevue-Stratford Hotel. The meeting rooms in the Bellevue-Stratford Hotel were, in many cases, quite unsatisfactory,

being often too small, inadequately air-conditioned to combat the very hot weather that prevailed during much of the meeting widely scattered throughout the hotel, and also quite noisy. The elevator service in the hotel was totally inadequate to give the service necessary for a major meeting of this type. In spite of these difficulties, however, the meeting was well supported and was good technically.

The membership of the Society is now over 9,000. It was a matter of great gratification to the writer that, at this meeting, he was one of nine members elected to the Fellowship of the Society. It is of interest to note that another of these nine is a former Mines Branch employee, namely Dr. Ralph E. Carter, now at the General Electric Research Laboratory, Schenectady, N.Y. The certificates of Fellowship were presented by Dr. Elburt F. Osborn, the retiring President of the Society and Vice-President of the Pennsylvania State University, at the conference banquet, held on the evening of Tuesday, May 4th.

A list of the papers presented attended by the writer will be given in this report. Details will then be given of some papers that held a particular interest to the writer. Some comments will then be given concerning the other functions held as part of the meeting and also concerning the plant trips that were available and, in particular, the one in which the writer participated. Some general comments on the meeting as a whole follow.

PAPERS ATTENDED BY THE WRITER

Details of all the papers presented at this conference are given in the April 1965 issue of the American Ceramic Society Bulletin on pages 297 to 417. This Bulletin gives the names of the authors, their location, and an abstract of the papers presented, and reference should be made to it for further information concerning the papers attended.

The papers attended in the Basic Science Division were numbered 7-B-65, 12-B-65, 13-B-65, 24-B-65, 25-B-65, 37-B-65, 54-B-65, 56-B-65, 60-B-65, 75-B-65, 76-B-65, 77-B-65, 78-B-65, 79-B-65, and 83-B-65. Sessions dealing with the following topics were held:

a) Crystal Growth and Crystal Structure;

b) Compaction and Sintering;

c) Fracture and Deformation;

d) Nucleation Phenomena: Theory and Experiment;

e) Deformation, Elastic and Expansion Properties;

f) Nucleation and General Studies;

g) Decomposition and Vaporization Studies;

h) ZrO_2 and Defect-Structure Systems;

j) Phase Equilibrium Studies; and

k) General Papers.

In the Electronics Division, the writer attended papers 1-E-65, 3-E-65, 4-E-65 and 10-E-65. These dealt predominantly with magnetic ceramics and with lead zirconate-titanate. He also attended three papers in

Symposium No.4, 1-S4-65, 2-S4-65 and 4-S4-65, which dealt with laser materials and one paper 9-S5-65 in Symposium No.5, dealing with thin films and ceramic substrates. One paper, 24-G-65, presented before the Glass Division, dealing with alumino borate melts was also attended.

PAPERS OF SPECIAL INTEREST

Paper 54-B-65 Ionic Field Strengths as Criteria for Compound Formation in Oxide Systems.

The ionic field strength, IFS, proposed by Dietzel, (IFS = $Z/(Tc + TA)^2$) was used to correlate results of studies on lithium oxide-rare earth oxide systems and also on divalent oxide systems. The critical IFS difference of 0.30 corresponded to significantly reduced reactivity and instability of the compound produced in the lithium oxide-rare earth oxide systems. No reaction was observed for values less than about 0.28 (Sm-Li). Reactions did occur for divalent oxide systems where the differences were less than 0.1. Compound formation is attributed to formation by the more electronegative cation of an expanded SiO_2-like lattice with large holes in it. Cations which are large enough to fill the holes then stabilize the lattice, and a compound is observed. Papers of this type, in which attemps are made to systematize the observed properties of inorganic compounds by relating them to their electronic structure and ion size variations across the Periodic Table are very useful. This paper was a good example of such work and an attempt will be made to obtain a copy thereof for detailed perusal and circulation to interested parties in the Mines Branch.

Paper 76-B-65 Phase Equilibria at Liquidus Temperatures in the System Cobalt Oxide - Iron Oxide - Silica in Air.

The quenching technique has been used to determine phase relations at liquidus temperatures in the system cobalt oxide-iron oxide-silica in air. Crystalline phases coexisting with liquids in the system are silica, cobalt orthosilicate (CO_2SiO_4) with olivine type structure, a spinel solid solution ($(Co, Fe)_3O_4$) and an oxide solid solution ((Co, Fe)O) with periclase type structure. The lowest liquidus temperature is 1313°C, at the isobaric invariant point where silica, olivine, spinel, liquid and gas are present in equilibrium. Another isobaric invariant point at 1328°C is characterized by the coexistence of olivine, spinel, (Co, Fe)O, liquid and gas. Composition relations among coexisting liquid and solid phases have been established in the areas where solid solution crystals are involved in the equilibria.

Paper 83-B-65 Phase Equilibria in the System Nb_2O_5-WO_3.

Thirteen new phases have been identified in the system Nb_2O_5-WO_3. Exact compositions of six of the compounds, having Nb_2O_5: WO_3 ratios of 6:1, 7:3, 8:5, 9:8, 1:1, and 4:9, have been deduced from single crystal x-ray diffraction data. Other phases are interpreted from powder data to occur at approximate compositions 15:1, 7:2, 16:5, 6:11, 2:5, 2:7, and 1:49. Thermal stability of the phases has been found to be related to the size of the structural blocks which form the basis of the crystal structures of the compounds. Discrete stoichiometric, structurally related compounds

can be identified in this system from single crystal data, rather than the "nonstoichiometric-solid solutions", frequently postulated when no single crystal data are available.

Paper 3-E-65 Processing Study of Barium-Cobalt Ferrites.

Barium-cobalt ferrites have high permeabilities at uhf frequencies, a property of value for broadband ferrite radar absorbers. Because ceramics displayed inferior properties, a processing study was made to determine the causes of low performance. Factors considered included calcination, sintering additives, time and temperature. The difficulty was shown to be due to sluggish diffusion which retards crystallization of the 3 BaO.2 CoO.12 Fe_2O_3 phase from the oxides. It was mentioned that the addition of bismuth oxide, Bi_2O_3, often gives enhanced sintering behaviour in the case of ferrites.

Paper 4-E-65 Particle Size Distributions of Milled Ferrite Powders.

Particle size distributions of milled ferrite powders have been determined using polished section microscopy. Errors due to agglomeration of particles are thereby avoided. The procedure involves dispersion of the powder in an epoxy mountant, preparation of a polished section, measurement of the powder cross sectional area distribution, and conversion of the area distribution to the particle size distribution. The weight fraction of powder visible with the microscope is measured by point counting. Correlations among milling time, energy input, mean size and dispersion of size are presented for ball milling and vibratory milling under various conditions. In view of the potential interest of the Mineral Sciences Division in the subject of ferrites, this was a useful paper and an attempt will be made to acquire a copy of it from the author. The ferrite mainly used in this study was the magnesium-manganese compound. It is considered that the results obtained by the technique described could very probably be processed by the recently acquired computer in the Mineral Sciences Division.

Paper 10-E-65 Densification and Grain Growth of Hot-Pressed Lead Zirconate - Lead Titanate Ceramics Containing Bismuth.

Grain size and bulk density were studied as functions of temperatures, time and pressure on a 65/35 (Zr/Ti molar ratio) lead zirconate-lead titanate composition containing two atom per cent bismuth. The grain growth and densification rate processes were found to be measurable in the temperature ranges of 1050-1300°C and 700-1100°C, respectively. Grain growth as a function of time followed a 1/3 power law; i.e., G_s (Grain size) = kt 1/3. An activation energy of 88.5 kcal/mole was calculated. Densification was found to be a two stage process; an initial rapid stage of densification and a final slower stage. The initial densification

was found to behave viscously with an activation enrgy of 36.7 kcal/mole. Results indicated that densification was sensitive to stoichiometry.

Paper 4-S4-65 Growth of Garnet Single Crystals by the Floating Zone Technique.

The floating zone technique of crystal growth has been adapted for rare-earth aluminum garnets. Since induction heating methods cannot be used to melt these materials, an arc image furnace utilizing a 2500 watt xenon lamp as a power source was employed to produce the molten zone. A detailed description of the heating system and the crystal puller was given. Actual operation of the equipment was discussed with particular attention given to unique problems associated with raw material preparation, zone stability, thermal cracking and annealing of garnet crystals.

Boules of $Y_3Al_5O_8$, $Y_{2.92}Nd_{0.08}Al_5O_8$ and $Dy_3Al_5O_8$ have been grown. Crystal properties and solid melt equilibria which permit growth by a floating zone technique with an arc image heat source were discussed. Boules 5 mm diameter by 75 mm have been grown. Data on the laser threshold energies for crystals grown by this method were presented. In view of the interest in crystals of yttrium iron garnet in the Mineral Sciences Division at present, the author presenting the paper was asked to supply a full copy thereof at his convenience. This he agreed to do as soon as it had been cleared by his company (The Bell Telephone Laboratories, Murray Hill, N.J.). Whether or not the technique would be applicable to our Division's interests, however, is not certain, largely due to the incongruity of melting of the yttrium iron garnet, as opposed to the congruity of melting of the yttrium aluminum garnet, the material studied in the work described in this paper.

GENERAL REMARKS

Associated with the technical sessions described in the foregoing sections, several other functions forming part of the meeting as a whole were attended by the writer. These will now be described.

a) On Saturday afternoon, May 1 and Sunday morning, May 2, a two-part panel discussion was held as a joint activity of the Ceramic Educational Council and the National Institute of Ceramic Engineers. The main theme of this discussion was University Research in Ceramic Science and Technology. The University viewpoint was presented in the first portion of the discussion by a group of seven university professors from U.S. schools having departments of ceramics, ceramic engineering, or metallurgy with ceramic specialization. They represented quite a wide distribution geographically and presented a review of the extent of research in these topics being conducted in their own and neighbouring schools, with a survey of the subjects being studied. A general need for industrial financial support and sponsorship was expressed, particularly for grants "with no strings attached" as to limitations or restrictions of subjects to be studied. The second half of the discussion, held on the Sunday morning, presented the industrial viewpoint and featured ten speakers from a wide spectrum of companies that were either manufacturers or users of ceramics of various types. Their general thesis was by way of a complaint that universities seemed generally unwilling to engage in the fundamental work necessary, in many instances, for the solution of ad hoc problems. In summary, it may

be said that nothing very much that was new transpired at this panel discussion; there was, however, a generally accepted view that more, and still more fundamental knowledge in the field of ceramic science was necessary and that every encouragement should be provided to increase the number of ceramic schools in the country and the size of their graduating classes.

b) On Sunday afternoon and evening the Annual Student speaking contest was held. This consisted of short papers on original or other work presented by final-year students from the various ceramic schools in the United States. Prizes were given for the best presentations.

c) The Annual Business Meeting of the Society was held on Monday morning, May 3. At this meeting, announcements were made of the award of the various medals of the Society and of the election to Honorary Membership of two distinguished members, namely Dr. G.W. Morey, late of the Geophysical Laboratory, Carnegie Institution of Washington, D.C., and now of the U.S. Geological Survey and, posthumously, Mr. R.R. Danielson of M. and T. Chemicals, Inc., a well-known worker in the field of enamels. These awards were followed by the Orton Memorial Lecture, an annual event in which an address on a ceramic topic is given by an outstanding speaker. This year's lecturer was Dr. Frederick Seitz, President of the National Academy of Science. His topic was "Current Trends in Solid State Science".

d) On Wednesday morning, May 5, the Annual Business Meeting of the Basic Science Division of the Society was held. Some matters of interest were brought forward at this meeting. Firstly, it was decided that,

for future Divisional Meetings, long (or 1,000-word) abstracts would be prepared for the papers to be presented thereat, as well as the normal short abstracts. These long abstracts would be collected and printed 2 to 4 weeks ahead of the date of the meeting if at all possible, and circulated to those intending to participate in the meetings. Secondly, subject to the expected approval of the Board of Trustees, a page charge of $40.00 (forty dollars) per page would be levied for publication of papers in the Journal and the Bulletin of the American Ceramic Society. One hundred free reprints would be supplied to the senior author of such papers. This arrangment would come into force with papers published after January 1, 1966, without regard to the date of submission. Publication of the papers is not conditional upon the payment of this page charge, nor is their approval by the board of referees, who will not be advised as to whether the page charge will or will not be paid. This procedure has been instituted to augment the revenue of the Society and to offset the increase costs of publication, and is in line with the practice of an increasing number of technical journals over the past few years.

e) On Thursday, May 6, a group of plant visits was arranged. That in which the writer participated was to the U.S. Army Electronics Laboratory at Fort Monmouth, N.J. For participants of other than U.S. citizenship, special clearance was necessary in order to gain access to this establishment. In the writer's case, this clearance was arranged through the good offices of the Defence Research Board. About 50 members of the Society participated in the visit to these laboratories. The laboratories are

located in the northeast part of New Jersey, quite close in a straight line from New York City and a two-hour bus run from Philadelphia. The laboratories are built in the form of a hollow hexagon and are very extensive in scale. On arrival, the participants were taken to an auditorium where the administrative and scientific organization of the laboratory was explained by one of its senior officers. A film depicting several of the recent achievements of the laboratory's scientists and technologists was then shown. The subjects covered micro-miniaturization of communications equipment, satellite and space vehicle technology, the use of laser beams in range finders and other similar topics. The party was then divided into three groups and proceeded on a tour of the laboratory facilities which spanned about one hour before lunch and two hours after lunch. The sections visited included:

(i) Ceramics laboratory – dealing with the development of micro-ceramic parts for electronic communications devices;

(ii) Super-pressure laboratory – in which phase studies at thousands of kilobars pressure are conducted using a 6-anvil press;

(iii) Crystal Growing laboratory – in which laser materials, garnet and other types of crystals are grown by the Czochralski, Verneuil, flux-melt and other techniques;

(iv) Laser laboratory – in which a laser-operated range finder was demonstrated; it gave an accuracy of a few inches when sighted on objects a mile or more away, the use of such instruments

on the combat field is, of course, quite apparent;

(v) Quartz Processing laboratory – showing the various stages of growing, cutting, polishing and orienting of quartz crystals for use in piezoelectric and optical devices;

(vi) Thin Film laboratory – in which the techniques for the production of super-micro-printed circuits were demonstrated;

(vii) Micro-assembly Techniques laboratory – associated with the immediately preceding demonstration – radio-transmitting and receiving sets completely enclosed within containers a half-inch cube in size were on view;

(viii) Electron microbeam probe, electron microscope and X-ray crystallography laboratories were also on view.

This was a very interesting visit and, although obviously much was being done concerning which nothing could be said for security reasons, sufficient material was on display to demonstrate the remarkable advances achieved by electronics and related technologies in recent years.

In conclusion, it may be stated that, in spite of the aforementioned difficulties of the Bellevue-Stratford hotel, it was a generally good meeting. The opportunity to meet with and to talk to the leaders in ceramic and related science and technology is particularly valuable and assisted materially in keeping the members of the Mines Branch staff who attended this Conference, in touch with recent developments in relevant fields. Continued support of both the American Ceramic Society and its Annual and Divisional Fall Meetings by several members of the Mines Branch staff is to

be actively encouraged. The writer is grateful for the opportunity of participating in this year's Annual Meeting.

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